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Effect of organic amendment and Trichoderma harzianum on strawberry growth and root rot caused by Phytophthora fragariae in strawberry plant

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DEDICATION

To my family:
To my father soul , Mother, , my brother Nazzal and naeif soul ,Wife ,daughter zain , sisters and brothers with their families.

To my supervisor and co- supervisor, and
To all friends, for their effort and support
To my home, Jordan with love

Nail Salameh Al-Mulhan

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Nail Salameh Al-Mulhan

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List of Abbreviations

BCAs	biological control agents
Ca	Calcium
CFU	Colony form unit
Cm	Centimetre
CRD	Complete Randomized Design
c.v	Coefficient of variance
EC	Electrical conductivity
GC/MS	Gas Chromatography Mass Spectrophotometer
Gm	Gram
ha	Hectare
K	Potassium
Lsd	Low significant differences
Mg	Magnesium
Mn	Manganese
mg	milligram
N	Nitrogen
Na	Sodium
P	Phosphorus
ppm	part per million
PDA	potato dextrose agar
PGPM	plant growth promoting microorganisms
V/V	Volume / Volume

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Abstract

Effect of organic amendment and Trichoderma harzianum on strawberry growth and root rot caused by Phytophthora fragariae in strawberry plant

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Mu'tah University, 2012

The investigation was carried out under partially controlled glasshouse conditions, at the Agricultural Research Station, AL-Rabbah, Mu'tah University, in the growing season (2011). To evaluate the potential use of organic manure (poultry and sheep). 0, 20 and 40 tons/ ha .and bio-control (***Trichoderm harzianum***) on vegetative growth, macro nutrients content and the response to root rot caused by (***Phytophthora fragariae***) of strawberry (***Fragaria xananassa*** Duch) cultivars (albino).

The result showed that all application organic manure was increased vegetative growth and root . When application of bi-control and manure increased the shoot growth with or without bio-control. While the experiments showed that significant effect in root fresh weight with poultry manure When the pathogen was present the fresh root weight is increased with sheep manure. The dry shoot weight increased when apply of the two type of organic manure and significantly effect when were added the bio -control and pathogen present or absent they will be increased of dry weight. While thy dry root weight was increased with the manure types and levels compared with control. The total leaf number significantly affected with manure type and levels and also the bio- control. The total number of runners total was increased with increased of manure levels and bio -control. When pathogen was present the number of runners increased with all treatments. Nitrogen content was doubled and has significant effect with bio- control to all treatments when the pathogen was absent .Nitrogen content was decreased when the pathogen present with manures and bio-control was absent in both part of plants. Application of organic manures and bio-control increased the phosphorus content in plant and increased with manures levels. Application of bio -control to all treatments increased phosphorus in shoot part compared with that of the control. Treatments with bio-control and with pathogen or not it was increased the potassium level in shoot . in the other hand the potassium content was increased in root too. When added bio -control and present of pathogen or not. Furthermore, addition of *Trichoderma* increased vegetative growth parameters,shoot and root N , P , and K content in presence or absence of *phytophthora*.

Disease percentage and diseases severity was increased when we did not application any amount of organic manure its reached above 70% in case of not added manure and bio -control .

الملخص

تأثير مخلفات الدواجن والاغنام واستخدام المقاومة الحيوية على نمو نبات الفراولة ومقاومة عفن الجذور

نائل سلامة الملحان

جامعة مؤتة، 2012 م

أجريت التجربة على نبات الفراولة تحت ظروف البيت الزجاجي التابع لمحطة البحـوث الزراعية في جامعة مؤتة خلال الفترة (2011/8/1 – 2011/11/16) وكان الهدف من الدراسة هو تقييم تأثير نوعين من السماد العضوي المختمر، سماد الدواجن والأغنام بنسب 0 2 ،0 4 طن للهكتار الواحد وإضافة المقاوم الحيوي(*Trichderma harzianum*) لمقاومة فطر عفن الجذور (*phtophthora fargaria*) الذي يصيب جذور الفراولة. وأظهرت النتائج أن معاملات التربـة بإضافة الأسمدة العضوية إلى زيادة كل من الوزن الطري للنمو الخضري، والجذور، وأدى وجود المقاوم الحيوي مع هذه الأسمدة إلى زيادة الوزن الخضري بينما أظهرت الدراسة فروق معنويـة في وزن الجذور الطري مع معاملات سماد الدواجن. زاد الوزن الجـاف للمجمـوع الخـضري بوجود نوعين السماد العضوي، وأظهرت النتائج بأن إضافة المقاوم الحيوي، وبوجود الممـرض، أو عدمه زيادة في الوزن الجاف، بينما زاد الوزن الجاف للجذور بزيادة مستويات هذه الأسـمدة مقارنة مع الشاهد. تأثر معدل عدد أوراق النبات معنويا بنوع السماد، ومستواه وكـذلك بوجـود المقاوم الحيوي. زاد معدل عدد المدادات بزيادة نوع السماد الحيواني و بوجود المقاوم الحيـوي، تضاعف محتوى النبات من النيتروجين، وبفروق معنوية عند إضافة المقـاوم الحيـوي لجميـع المعاملات في حالة غياب المرض، وقد انخفض المحتوى من النيتروجين في حالة وجود الممرض مع الأسمدة، وغياب المقاوم الحيوي لكل من الجزء الخضري والجـذور.أدت إضـافة الأسـمدة العضوية إلى زيادة محتوى الفسفور في النبات، وزاد بزيادة المستوى، وإضافة المقاوم الحيـوي إلى جميع المعاملات زاد كمية الفسفور في المجموع الخضري مقارنة مع عدم إضافته، كما وأدت إضافة نوعي السماد، والمقاوم الحيوي إلى زيادة نسبة الفسفور في الجذور.إضافة المقاوم الحيوي زاد محتوى البوتاسيوم في الجزء الخضري، وكذلك زاد محتـوى البوتاسـيوم فـي المجمـوع الجذور.زادت نسبة إصابة الجذورو شدة المرض عند عدم إضافة أي نوع من الأسمدة الحيوانية، حيث وصلت إلى (70%) في حالة عدم وجود أي نوع من السماد، وعدم إضافة المقاوم الحيوي، وخفضت أنواع الأسمدة وبشكل معنوي مع المقاوم الحيوي نسبة المـرض مقارنـة مـع وجـود الممرض.

Chapter one
Theoretical background

Vegetable crops are considered as one of the main sources of human daily nutrition and this importance belong to the vegetable's contents such as vitamins, mineral salts, carbohydrate and proteins. In Jordan, the average area planted with vegetable in 2008 was about 41870.2 ha and their productivity in the same year was about 1417340.2 ton. (Agricultural statistics, 2008).

In the world, the average area planted with strawberry in 2004 was about 214.2 thousands ha and their productivity in the same year was about 3.1 million ton. In Jordan, the area increased from 2.75 ha (55 plastic house) in 1989 with productivity 17 ton to 55.4 ha (1107 plastic house) with total productivity 959 ton in 2004. (Fao statistics, 2004).

Strawberry (*Fragaria X ananssa*) belongs to Rosaceae family. According to FAO (2004) world strawberry production reached about 3.1 million tons and the total planted area was estimated at 214.200 ha. The highest production (840,000 tons) was recorded in the USA. In Jordan, strawberries are mainly cultivated for fresh consumption for local and export markets in the winter growing season that extends from December to March. It has been produced at a significant scale in Jordan for the last 20 years (Guillaud, 2004). The area cultivated by strawberry in Jordan was about 30 ha in the Jordan Valley and 15 ha in the highland in protected culture. The total annual production was about 1500 to 2000 tons (Guillaud, 2004).

Strawberry is actually herbaceous perennial plant the nutritional value of strawberries makes them an excellent choice for home fruit growers, one cup (250ml) raw strawberries juice contains 39-55 calories, one gram of protein, 0-1 gram of fat, 10, 1-13 gram of carbohydrates, significant amount of ascorbic acid (70-90 mg), 1.3-3.6 gram fibre, 0.6-1 mg iron, 22-29 mg calcium, 29-30 mg phosphorus, 262 mg potassium, 0.2 mg zinc, 0.4 mg niacin (Butler, 1998; Pellet and Shadarevian, 1970; Penner and Dray; 1995; Steingger and Janssen, 1996).

Growing vegetable crops in Jordan is faced by different kind of problems, which include both biotic and a biotic factors. Some of these problems are poor soils fertility , low organic matter, low water holding capacity and high pH(Al-Karaki and Al-Omoush,2002; Ouda and Mahadeen,2008).To overcome low soil fertility, farmers usually apply high amounts of chemical fertilizers to enhance crop growth and productivity per unit of area (Al-Karaki,2002).However, the use of high amounts of chemical fertilizer that leaches from the soil, and leads to increased runoff into surface water as well as leaching into ground water (Rosen and Horgan, 2009).Which affect the quality of both the environmental and

human health (Otero *et al*.,2005),and its not available the most farmers due to high cost.

Organic manure application can serve as alternative practice to fertilize the soil, due to its high nutritional value and to great enhancement effects on soil properties to provide essential minerals (Beckman, 1973). Including organic matter, water holding capacity, and soil structure, enhance soil biological activity and promoting soil aggregates(Al-Karaki,2004);Edwards and Lofty, 1982), hence improve crop yield.

Strawberry root rot caused by *Phytophthora fragaria*e is a serious disease in green house and open field in the temperate regions of the world. Fungicides and soil fumigants are used to control the disease. The toxicity of these compounds has led to a general trend to reduce their application in the soil. Several alternatives to these produces have been suggested to control the disease, including organic soil amendment (sheep and poultry manure) and biological control.

Organic soil amendment, such as animal manures and composts, were commonly used in agriculture production for their fertility value prior to the availability of chemical fertilizers. It is likely that these amendments also provided other benefits such as improved plant health due to reduction of pathogens (Lazarovits *et al*., 2000).The utilization of organic amendment in agriculture for plant fertility and management of soil microorganism populations peaked in the 1930 and was last detailed by Waksman (1927) and Waksman and Starkey (1931).

A fertilizer is any material, organic or inorganic, natural or synthetic, that supplies plants with the necessary nutrients for plant growth and optimum yield. Organic fertilizers are natural materials of either plant or animal origin, including livestock manure, green manures, crop residues, household waste, compost and woodland litter. Organic nutrient sources are highly heterogeneous and vary in quality and quantity.

Soils with high levels of organic matter have a more complex and active micro-flora and fauna associated with their ability to suppress the activity of the root rot pathogen, *phytophthora* (Broadbent, 1974; Hoitink, 1999). Composts and manures harbour their own populations of microorganisms, and microbial populations change during composting (Hoitink, 1999).

Phytophthora spp. can also be controlled by using organic fertilizers such as manure and compost because they can stabilize soil pH and be appropriate for developing antagonistic microorganism (Aryantha *et al*., 2000; Linderman, 2003; Drenth and Guest, 2004; Liu *et al*., 2007). Organic matters can induce systemic resistance in plants due to the presence of microorganisms in composts (Hoitink *et al.*, 2000). It has been reported that certain plant growth promoting microorganisms (PGPM) could enhance defensive activity and stimulate plant resistance against soil borne

pathogens (Kilic-Ekici and Yuen, 2003; Zheng *et al*., 2005). It is important to choose the appropriate organic fertilizer for controlling disease because composition of organic matter has an important effect on organic fertilizers on susceptibility to *Phytophthora* development of plant diseases.

Phytophthora (de Bary., 1887) is a cosmopolitan genus of Oomycete obligate plant pathogens is containing approximately 60 described species (Erwin and Ribeiro, 1996). *Phytophthora* pathogens can cause many different diseases and disease symptoms on a wide range of plant species including black pod, root, stem and fruit rot, bud rot, black stripe, trunk canker and blight. The *Phytophthora* genus is formidable plant pathogens, the ability to produce different types of spores such as sporangia and zoospores for short-term survival and spread, and chlamydospores and oospores for longer term survival.

Trichoderma spp. is ubiquitous fungi in soil that are well known for their beneficial impacts in agricultural and forestry systems (Papavizas., 1985). *Trichoderma* strains have antagonistic activity against soil borne pathogens (Papavizas, 1985; Harman, 2000; Howell, 2003) and can stimulate plant growth even in the absence of disease (Kreutzer, 1965; Inbar *et al*., 1994). The fungus *Trichoderma harzianum* is a biological control organism against a wide range of soil-borne pathogens and has plant growth promote capacity. It has been shown that *T. harzianum* stimulated the growth of tomato plants (Chet, 1990; McGovern *et al*., 1992; Datnoff and Pernezny., 1998).

The objectives of this study were to

1- Evaluate the potential use of organic manure and *Trichoderma harzianum* on strawberry growth. As well as to establish the bio-control influence on root rot disease severity and incidence.

2- Evaluate the potential interactive use of organic manure and bio-control on the plant growth.

3 - Evaluate the use of *Trichoderma* spp. for reducing root rot *caused* by *Phytophthora fragariae*.

Chapter two
Review of literature

2.1. Strawberry crop

Strawberries belong to the Rosaceae family (smith *et al* .,1992). The garden strawberry (Fragaria *X ananssa* Duch)is a combination of two Native American Strawberries, hybrid. strawberry (Fragaria *X ananssa*)it was first called the″ pineapple ″ by Dutch horticulturists, and it is actually herbaceous perennial plant (Hassan, 2002; Poling, 1996; Domote *et al*., 2000). The nutritional value of strawberries makes them an excellent choice for home fruit growers, on cup (250 ml) raw strawberries juice contains-cultivar dependent-39-55 calories, on gram of protein ,0-1gram of fat,10.1-13 gram of carbohydrates ,significant of amount of ascorbic acid(70-90 mg),1.3-3.6 gram fiber,0.6-1 mg iron, 22-29 mg calcium, 29-30 mg phosphorus,262 mg potassium,0.2 mg zinc, 0.4 mg niacin(Butler,1998,Pellet and Shadarevian, 1970, penner and Dray, 1995. and Steingger and Janssen,1996). Strawberries are low in sodium and contain measurable quantities of ellagic acid, wich has inhibiting effects on chemically induced cancer(Poling,1996,and Torronen and Maatta,2002).In addition to fresh consumption , strawberries are widely used in the food industry ,to produce jams, jellies, slightly processed sliced berries, canned strawberries and juices . It is also used as an ingredient in other food products like yoghurt, ice cream, cake, breakfast cereals or chocolate bars(Haffner, 2002).

2.2. Cultural practices

Soil fertility is very important factor in plant growth enhance plant growth and crop yield (e.g. strawberry).Addition of organic soil amendment to soil is very important to enhance crop productivity especially in arid and semiarid regions (e.g. Jordan) which their soils are characterized by high pH, poor fertility and low organic matter. Applied fertilizers can be categorized into three types:-chemical, organic and Trichoderma ; which can be added either singly or combination at optimum rates to achieve balanced nutrient management in soil for crop growth.

2.3. Organic soil amendment

The intensive application of chemical fertilizers in intensive farming system has caused concern related to soil and water pollution, along with the potential health hazards for human and animals consuming polluted agricultural produces. These concerns have revived interest in organic soil amendment. Application of organic soil amendment leads to several advantages such as. Enhancement soil biological activity , enhancement

soil structure, enhance water holding capacity and improvement nutrient mobilization (Al-Karaki,2008).

However, slow rate of nutrient release in the soil, heavy application of organic soil amendment might induce accumulation of salt and some nutrient are not exist are considered as main disadvantages for organic soil amendment application (Wong *et al*.,1999).Therefore application of some factors such as *Trichoderma harzianum* might enhance beneficial effect of organic soil amendment.

2. 4. Effect of organic soil amendment on plant growth

Organic farming became very important in the agriculture sector of many countries and one of the several approaches to sustainable agriculture. So that, the effect of soil organic amendment on plant growth was studied by several researchers. Vermicompost improve plant growth of strawberry, tomato, and pepper plant (Norman *et al.*,20063) As well as Edwards (1988) found that vermicompost could promote early and vigorous growth of seedling. Furthermore, organic manure activity many species of living organism, which release phytohormones and may stimulate the plant growth. Norman *et al.*,*(*2003) reported that there was significant increased in leaf area of strawberry , and pepper plant from plots treated with organic vermicompost compared with those from plots treated with chemical fertilizer only. Addition of chicken manure significantly increased vegetative growth of brassica species (B. Carinta.and B. oleracea L.) compared with compost prepared from olive mill and cotton wastes(Walker and Bernal, 2004). Fresh and dry weight of tomato (plant and fruit) indicated a clear increase with application farmyard manure compared with other treatments(Radwan *et al*.,1993).The highest fresh weight of green house tomato was obtained from applying 30 ton / ha farmyard manure, followed by chicken manure 30 ton / ha (Tuzal *et al.*, 2003).Organic fertilizers increased fresh and dry weight of leaves, number of branches,of tomato plant compared with chemical fertilizers (Chanda *et al*.,2011). As well as fresh and dry weights of strawberry shoot were significantly increased with the addition of organic manure (Mahadeen.,2009). Application of 25 m^3 of farmyard manure/fed significantly favoured both branches and leaves/plant in pea compared with 0 and 12.5 ton/fed (El-Mansi *et al.*, 1999).

Manure and by-products of the seafood and livestock industries have been used by growers to maintain productivity of agricultural soils for millennia (Davey, 1996; Barker *et al*., 2000; Lazarovits, 2001). The living components in soils require carbon as an energy source, but there has been a chemical drip for the past 50 years with little organic energy input to the system.

Application of organic manure leads to several advantages such as : enhancement soil biological activity, enhancement soil structure, enhance

water holding capacity and improvement nutrient mobilization(Al-Karaki ,2008).However, slow rate of nutrient release in the soil, heavy application of organic fertilizer might induce accumulation of salt and some nutrient are not exist are considered as main disadvantages for organic fertilizers application (Wong *et al,*1999).Therefore application of some factor such as beneficial Trichoderma (*Trichoderma harzianum*) might enhance beneficial effect of organic manures application.

Organic mater is known to affect soil aeration, structure, drainage, moisture holding capacity, nutrient availability, and microbial ecology (Davey, 1996). Incorporating organic amendments and managing crop residues (type and quantity) have a direct impact on plant health and crop productivity. Crop rotation consisting of wheat, beans or legumes followed by either a fallow period or a green manure was frequently used in the time of ancient Greece and Rome (Karlent *et al*., 1994).

Organic fertilizers including farmyard manure, sheep manure and poultry manure may be used for the crop production as substitutes of the chemical fertilizers because the importance of the organic manures cannot be overlooked. Worldwide, there is growing interest in the use of organic manures due to depletion in the soil fertility. Economic premiums for certified organic grains have been driving many transition decisions related to the organic farming (Delate and Camberdella, 2004). Continuous use of fertilizers creates potential polluting effect in the environment (Oad *et al*, 2004). Synthesis of chemical fertilizers consumes a large amount of energy and money. However, an organic farming with or without chemical fertilizers seems to be possible solution for these situations (Prabu *et al.,* 2003). The integration of organic sources and synthetic sources of nutrients not only supply essential nutrients but also have some positive interaction with chemical fertilizers to increase their efficiency and thereby reduce environmental hazards (Ahmad *et al.*, 1996).

These production changes have been detrimental to soil health and water quality, leading to an increase in plant diseases and other pest problem, all within a relatively short period of time (Pimental *et al*., 1991; Hoitink and Boehm, 1999). Cook (1986) has argued convincingly that maintaining root health is a requirement for high yields in crops.

High yield for extended periods of crop cultivation in areas of China were associated with the use of organic source of fertilizer or waste products (Kelman and Cook, 1977; Shen, 1997). Such fertilizers contribute to root health by improving soil structure and reducing the negative impact of soil-borne pathogens Davis *et al.* (2001). According to Walker and Bernal.,(2007) olive mill compost had high organic matter ratio (82.5 %) than poultry manure (66.4 %) and both of them had higher ratio of organic matter than soil. Pavlou *et al*., (2006) also showed that organic matter ratio in sheep manure was significantly higher (72.0 %) than the soil (1.4 %)

Dede *et al*., (2006) showed that poultry manure had higher ratio of organic matter than maize straw (68.2 %) and municipal solid waste compost and lower than peat (79 %) and huzl nut husk (73.7%).

2. 5 Effect of amendment on plant diseases

Phytophthora species are an important group of fungi that cause disease in a wide range of different plant species. Strawberry can be attacked by several viral, bacterial and fungal diseases. Of the fungal diseases under the most important pathogens are *Phytophthora fragariae* var. *fragariae* and *Phytophthora cactorum,* which causes red stele and crown rot disease of strawberry respectively with substantial economical damage in strawberry production (Mass 1984; Seem-llur, 1998).

Cultivation of strawberry is mainly depending on the use of chemicals to control root rot. In most countries two different fungicides viz. Ridomil with metalaxyl and Aliette with aluminium-fosetyl as active substance are used against these pathogens (Anonymoys, 1999). However, in some cases where metalaxyl has been used for several years, resistant strains of *P. fragariae* var. *fragariae* have been recognized (Seem-llur and Sun, 1989; Nickerson, 1998). Control of these pathogens is often achieved by chemical means, but the toxicity to humans of the chemicals used has now led to an emphasis on research to and alternative, more benign, no chemical methods. Approaches have included breeding, changed cultural practices and, in recent years, biological control. This latter strategy has involved identifying organisms that exhibit a natural antagonism towards *Phytophthora* species and applying them to the susceptible plant or system.

Application of organic matter input such as animal manures has been shown to suppress a range of soil-borne diseases (Noble and Conventry, 2005), this due to a range of mechanisms including enhance microbial activity, induced resistance in roots to pathogens and release antimicrobial compounds (Xialo, 1998).Organic amendment at 25% (w:w) concentration stimulated *Trichoderma harzianum* , enhanced microbial activity against *Fusarium oxysporum* in the soil , reduced pathogen populations and tomato wilting (Barakat and Al-masri,2009).

2.6 Effect of organic soil amendment on plant growth and diseases control.

Organic mulching is an ancient gardening and farming practice developed to nature favorable physical, chemical, and biological environments in the soil. Mulching with organic material stimulates plant root growth, increases nutrient uptake, decreases evaporation from the soil, increases soil water-holding capacity, reduces surface water runoff, facilitates drainage, regulates soil temperature, and provides a rich substrate for soil microbes (Chen, 1987, Chen, 1988, Ribeiro, 1991).

Dry matter yields of brassica chinsis and zea mays were higher in plots receiving manure compost amendment compared with that had no manure (Wong *et al*.,19989).Different applied rates(15 , 30 and 60 ton/ acre) of compost application increased the dry weight of broccoli and lettuce (Shiralipour *et al*.,(1996). Vermiccompost improve plant growth of strawberry, tomato, and pepper plant (Norman *et al*., (2003). On the other hand, 36 ton/ha of poultry manure caused strawberry vegetative burn during the first 3 seasons, which may have reduced yield (Albregts and Howard (1981). There was significant increased in leaf area of strawberry, and pepper plant from plots treated with organic vermin compost compared with those from plots treated with inorganic fertilizers only (Norman *et al*., 2003).There was a significant differences in the leaf area of onion only between sheep manure at levels of 20 and 40 ton/ha with 20 ton/ha of poultry manure in the 1997 season (Abedelrazzag, 2002).

Soils with high levels of organic matter have a more complex and active micro flora and fauna associated with their ability to suppress the activity of the root rot pathogen, *Phytophthora* (Broadbent, 1974, Hoitink, 1999).

Composts and manures harbor their own populations of microorganisms, and microbial populations change during composting (Hoitink, 1999). Depending on their state of decomposition and quality, composts may result in the amended soil becoming either conducive or suppressive to disease (Hoitink, 1999, Hoitink, 1996). Hoitink et al. (Hoitink, 1996) proposed composting to high temperatures to ensure that pathogens are killed, followed by the amendment of mature composts with exotic biocontrol agents as a way of improving the reliability of composts. In addition to sometimes increasing the severity of plant diseases, manures may also cause phytotoxicity. Many plants belonging to the family Proteaceae, for example, evolved on phosphorus-deficient soils and have a low tolerance for increases in soil phosphorus levels resulting from compost amendments (Leake, S., 1996).Also, Abd El-Moez *et al*.,(2001) found that application of chicken manure increased plant growth of paper fresh and dry weights in vegetative compared to control by 19%.

2.7 Effect of use bio control *Trichoderma* spp. on plant growth and control diseases.

Plant diseases play a direct role in the destruction of natural resources in agriculture. In particular, soil-borne pathogens cause important losses, fungi being the most aggressive. The distribution of several phytopathogenic fungi, such as *Phythium*, *Phytophthora*, *Botrytis*, *Rhizoctonia* and *Fusarium*, has spread during the last few years due to changes introduced in farming, with detrimental effects on crops of

economic importance. In addition, not only growing crops but also stored fruits are prey to fungal infections (Chet *et al*., 1997).

Chemical compounds have been used to control plant diseases (chemical control), but abuse in their employment has favored the development of pathogens resistant to fungicides. Unfortunately, the more specific the effect of a chemical on an organism, the greater the probability of decrease By contrast, the use of microorganisms that antagonize plant pathogens (biological control) is risk-free when it results in enhancement of resident antagonists. Moreover, the combination of such biological control agents (BCAs) with reduced levels of fungicide (integrated control) promotes a degree of disease suppression similar to that achieved with full fungicide treatment (Monte E (2001). The effect through genetic shifts in the population, whereas fungicides of broad spectrum produce undesirable consequences on non-target organisms (Tjamos *et al*., 1992).

One group of micro organisms that show potential to control disease induced by *Phytophthora* species and other fungal pathogens in this way is the *Trichoderma* spp fungus especially *Trichoderma harzianum* (Lewis *et al*., 1998; Al-Ameiri, 2001, 2007 and 2009), The potential of *Trichoderma* species as bio-control agents of plant diseases was first recognized in the early 1930s, and in subsequent years, control of many diseases has been added to the list (Aluko *et al*., 1970). (Sharon,*et al* .,2001).and (Zhang, *et al.,* 1996). Fungal species belonging to the genus *Trichoderma* are worldwide in occurrence and easily isolated from soil, decaying wood, and other forms of plant organic matter. They are classified as imperfect fungi, in that they have no known sexual stage. Rapid growth rate in culture and the production of numerous spores (conidia) that are varying shades of green characterize fungi in this genus. The reverse side of colonies is often uncolored, buff, yellow, amber, or yellow-green, and many species produce prodigious quantities of thick-walled spores (chlamydospores) in submerged mycelium (Gams *et al*., 1998).

One of the most important characteristics necessary for acceptance and effectiveness of bio-control agents is their ability to survive in the environments other than their origin and colonize plants roots during certain period of time to control plant pathogens (Nemec *et al*., 1996). In other studies all strains have maintained their populations at high levels after inoculation in the period of 4 weeks (Sivan and Chet, 1993; Nemec *et al.,* 1996; Datnoff and Pernezny, 1998).

This fungus colony the roots of most plants, including many agricultural crops, and are of major ecological importance. They usually provide several benefits; including enhanced nutrition and protection against pathogens.

Trichoderma strains are commercially available for field and greenhouse production of several crops (Harman, 2000; Al-Ameiri, 2001).

Trichoderma spp. has been shown to inhibit the growth of *Phytophthora* spp. and reduce the diseases caused by them (Harman,. 2000; Kelley 1976; Smith, 1990; Washington. 1999; Wilcox, 1992).Disease suppression by bio-control agents is the sustained manifestation of interactions between the plant, the pathogen, the bio-control agent, and the microbial community on and around the plant and the physical environment (Handelsman, 1996).Species of *Trichoderma* are studied primarily for their ability to control plant disease through antagonism, rhizosphere competence, enzyme production, induction of defense response in plants, metabolism of germination stimulants, and beneficial growth of the host following root colonization (Bailey. 1998; Benhamou. 1993; Elad, 1981; Elad, 1987; Gams, 1998; Jeffers 1986; Lindsey, 1967 Washington,.. 1999;Weindling. 1937; Wright, 1956; Zimand, 1996).

Determination of these effects depends on many interactions that take place in the soil among *Trichoderma* spp., other microorganisms, the plant root, and the soil environment (Bailey, 1998).

The concept of adding biocontrol agents into a planting mix or applying directly to the roots of transplants is an efficient, inexpensive means to provide a more vigorous transplant with disease protection when it is transplanted to the field (Nemec *et al*, 1996). In addition to their biocontrol activities, *Trichoderma* spp. has been reported to promote plant growth (Chang *et al*, 1986; Inbar *et al*., 1994). Possible explanation of this phenomenon includes control of minor pathogens leading to stronger growth and nutrient uptake (Ousley *et al*, 1993); the results indicated that *T. harzianum* strains had a positive effect on tomato transplant growth.

2.8 Plant macro nutrients content

Organic matter increased the N content by radish and spinach plants at different stages of plant growth, due to the beneficial effect of organic matter in improving the nutritional status in the soil .The content of N.P.K. in mixture of (organic media + super phosphate) was higher than using (super phosphate with soil only (El-Dewiny *et al*., 2006). Poultry manure is an excellent organic fertilizer, as it contains high nitrogen, phosphorus, potassium and other essential nutrients. In contrast to chemical fertilizer, it adds organic matter to soil which improves soil structures, nutrient retention, aeration, soil moisture holding capacity and water infiltration (Deksissa *et al*., 2008). It was also indicated that poultry manure more readily supplies P to plants than other organic manure sources (Garg and Bahla, 2008). Poultry manure is a valuable organic fertilizer and can serve as a suitable alternate to chemical fertilizer. Poultry manure application registered over 53% increases of N level in the soil, from 0.09% to 0.14 % and exchangeable cations increase with manure application (Boateng *et al*., 2006). In agriculture, the main reasons for applying PM include the organic

amendment of the soil and the provision of nutrients to crops (Warren *et al.*, 2006). Total N was remained unchanged by application of liquid cattle manure, N and P fertilization (Theodora *et al.*, 2003). Large application of mineral fertilizer (300,500) and 1000kg/ha and organic (green mulch) had Mn concentration below the estimated sufficiency in all fertilizers regimes in Chinese cabbage at harvest (Magnusson, 2002).

Nitrogen concentration in cauliflower seedling increased significantly with increasing compost percentage in the media (compost: peat-lite) (20:80) %, (40:60) %, (60:40) %, and (80:20) % (Kahn *et al.*, 2005). Muskmelon tissue showed no significant differences between N. P. K concentrations with increasing composting time (22, 40, and 90) day (Roe and Cornforth, 2000).

Under highly saline soil, tomato and sugar beet showed no significant differences between using (soil + olive mill compost) and (soil + dairy manure) in NO_3 concentration. But dairy manure had significantly higher NO_3 concentration than olive mill compost in sea beet. (Walker and Bernal, 2007).

In the same study, tomato, sugar beet and sea beet showed no significantly differences of K concentration between dairy manure and olive mill compost (Walker and Bernal, 2007). (H_2PO_4) concentration in shoot of tomato and sugar beet had no significant differences between dairy manure and olive mill compost; while when compared before used, dairy manure treatment was significantly higher in H_2PO_4 concentration than olive mill compost (Walker and Bernal, 2007).

Arisha and baradisi,(1999)found that highest contents of N, P and K in the different potato plant tissue achieved by application of NPK fertilizers up to 60+45+75 kg/fed or farmyard manure up 45m^3/fed.There were significant increase in N, P and K concentration in cucumber fruits by application of poultry manure and compost(Abo-Hadid *et al.*,2000).William and Greig,(1972) indicated that organic manures resulted in significantly higher P concentration in spinach plant tissue than did mineral fertilizer.

Broccoli leaf nitrogen content was increased by the application of organic manure and chemical fertilizer(Ouda and Mahadeen.,2008).The highest strawberry leaf-N content obtained with application of 25 ton/ha of organic manure(Mahadeen.,2009).Also,Maftoun *et al.*,(2004) indicated that the concentration of N in the spinach plant increased with increasing the level of poultry manure. Preusch *et al.*(2004)reported that leaf P in strawberry plant treated with composted and fresh poultry litter was higher than synthetic fertilizer.

2.9 Leaf numbers, area and runner numbers

Poultry manure where increased leaf number of cucumber (***Cucumis sativus*** **L.)** under green house conditions **(Azarmi**, *et al*. (2009). A significant increase in leaf area of tomato seedlings was obtained from plot treated with (30%:70%) compost: peat compared with those from plot treated with 100 % peat **(Herrera *et al*., 2007).** Nwakaego, *et al*, (2011) found that the organic manures increased the number of branch / plant when used as fertilizers on Cassava plant.

Poultry manure applied at 6.6 and 9.9 ton/ha were higher than 3.3 and 0 ton/ha of poultry manure in promoting watermelon vine length and number of leaves (Dauda *et al*., 2008).According to Kandil and Gad, (2010) the best plant height, branches and leaves number, leaf area, root length, were record by tomato plants supplied with chicken manure.

Chapter Three
Design and Methodology

The present study was carried out under controlled glasshouse conditions, at the Agricultural Research Station, AL-Rabbah, Mu'tah University, (Latitude: 3116, N; Longitude: 3545, E; Elevation: 920m) in the 2011/2012 growing season.

3.1 Experimental design and treatments

Strawberry (Fragaria *X ananssa* Duch) cv. Albino) transplant was used in this study. Strawberries transplanted were planted in plastic pots (20 cm diameter) containing 3 kg soil. Under greenhouse conditions.

This work was conducted to study the effect of two types of organic soil amendment at two levels and *Trichoderma harzianum* on strawberry growth and root rot caused by *Phytophthora fragaria*e.

Experimental treatments were arranged as factorial in a completely randomized design with three replications and two plants per treatment. The first factor was organic soil amendment (control, poultry manure (20 and 40 ton/ha) and sheep manure (20 and 40 ton/ha). The second factor was *Phytophthora fragaria*e (with and without) and the third factor was *Trichoderma harzianum (*with and without*) (Table 1).*

The following treatments were performed in this study:

3.2. Organic soil amendment treatment

Two types organic manure levels (poultry and sheep manure)were used with two levels(20 and 40 ton/ ha) Organic manure were obtained from Jordan valley company for Organic Fertilizer production(Jordan valley). Pots were received 80 g/pot and 160 g/pot which are equivalent 20 ton/ ha and 40 ton/ha, respectively.

3.3. *Trichoderma* treatments

Infected plants of strawberry grown under plastic houses that were collected from Al-Yadodeh location to isolate the *Phytophthora fragaria* from the infected plants on potato dextrose agar (PDA). The isolate were kept at refrigerator until used in the experiment. *T. harzianum* either isolated from a disease-suppressive soil from the same location by dilution plate method on (PDA)medium; the plates incubated at 25ºC until used in the experiment.

3.4: Soil and manures analysis

Representative soil samples were taken soils were used for analysis of some physical and chemical properties. Samples were oven dried at 70 ˚C for 72 hours; grounded and passed through 2-mm mesh diameter

screen. Soil samples were then prepared for pH and electrical conductivity (EC) measurements which were measured at 1:5 (W/V) ratios using a glass Electrode pH-Meter and EC meter as recommended by chapman and pratt, (1961).Total organic matter (OM) was determined by using potassium dichromate wet digestion method (Schnitzer,1982). Total nitrogen percentage was determined by using Kjeldal method N (Kjeldal) extract titrated with 0.01 of concentrated sulphuric acid. Available phosphorus (p) concentration of soil was extracted by ($NaHCO_3$) method by spectrophotometer (Watanbe and Olsen,1965). Available K contents of 5 gm soil was extracted by 1 N ammonium acetate and determined by flame photometer.(Table 2).

Table (1)
Layout of the experiment.

Soil amendment treatments and level (tons/ha)	**Pathogen** *Phytophthora fragaria*	**Bio control** *Trichoderma harzianum*
Control (0)	**With**	**With**
		Without
	without	**With**
		Without
Poultry (20)	**With**	**With**
		Without
	without	**With**
		Without
Poultry (40)	**With**	**With**
		without
	without	**With**
		without
Sheep (20)	**With**	**With**
		without
	without	**With**
		without
Sheep (40)	**With**	**With**
		without
	without	**With**
		Without

3.5: Soil infestations

Strawberry seedlings were directly transplanted into the plastic pots containing soil previously artificially infested with the pathogenic fungi and bio-control. Each of pathogen and bio-control was used at a concentration of 5g of infected wheat seeds / pots. Seeds of wheat were autoclaved twice two day's one day interval at 121^{o}C for one hour at six flasks (one litter volume) contains 500 g wheat seeds. Each of pathogen and bio-control have two flasks of wheat seeds were inoculated by suspension of 10^8/ ml (CFU), (counted with haemocytometer) from pathogen or bio-control and the others two flasks leaf without inoculums added as control treatments. Before seed used were dried at room temperature to remove the humidity.

3.6: Cultural practices

Uniform strawberry transplants (one month age) were planted on July 15th 2011 after one day from soil infestation; Irrigation commenced at a time of planting and continues daily from planting date to harvest date (2 months after planting).

3.7. Data collections

3.7.1. Fresh and dry weight of plants

At the end of experiment (60-days after planting) , each treatment was represented by fresh and dry of root and shoot of seedlings by cutting plants into two parts (root and shoot) after that fresh root and shoot were weighted. For dry weight determination, shoots and roots were taken and dried in an oven at 75C°for 72 hours to a constant weight and kept for mineral analysis.

3.7.2. Collection, preparation and analysis of leaf samples

Three youngest fully expanded leaves were selected to represent each treatment to estimate leaf area and tissue analysis (Tandon, 1995). Leaves were cut and dried at 75C°for 72 hours to the constant weight, grounded to pass through a 1mm sieve to reduce the material to a fineness suitable analysis using a mechanical grinder. Samples were kept in airtight plastic bags for chemical tissue analysis. Tissue samples were analyzed for N as outlined by Fleige *et al.,* (1971). One gram of dry samples was digested with sulfuric acid 68% in Kjeldahl digestion until sample become colourless and then titrated with 0.1N of H_2SO_4.

The other mineral concentrations in plant tissue were determined after nitric acid digestion. Phosphorus was determined according to Wantanbe and Olsen method (1965). Potassium in plant tissue was analyzed according to Meiwes *et al.,(* 1984).

3.7.3. Leaf area

Leaf area of seedlings for each treatment was measured using Photo electrical method software Version 6.0. Adobe Systems Incorporated). Leaves were scanned in computer (Nero software),

Photos of leaves were measured by pixel unit and then data translated to the cm unit, leaf area was calculated and compared with constant area of paper.

3. 7. 4. Leaves number and runners

Number of leaves and runners per seedling was counted at the end of experiment. Then average of leaves number per seedling was calculated.

3.8. Disease assessments

The average percentage of Phytophthora rots and disease severity on strawberry plants was recorded at the end of experiment. Percentages of disease were assessed by plating a segment from plant roots (0.5 cm) five segments / plate three plates /replicate/ treatment on potato dextrose agar.

Disease percentage was calculated as the average of infected segment to the total of infected segment.

Disease severity scored using a 0-5 scale(0: root healthy, 1: 20% root rot, 2: 40% root rot, 3: 60% root rot, 4: 80% root rot, 5: plant dead) and disease severity recorded on plants for each treatment. Disease index was calculated according to the following scheme:

$$\text{Disease severity} = \frac{\text{Sum of the rating value}}{\text{Total no. of plants/replicate} \times 5 \text{ (highest rating value)}}$$

Efficacy was calculated using the formula according to Abbot (1925):

$$\text{\% Dis. control} = \frac{\text{Disease index of control} - \text{Dis. index of treatment}}{\text{Disease index of control}} \text{X } 100\%$$

3.9: Statistical analysis

The treatments were replicated three times; all data obtained from the glasshouse were statistically analyzed by using MSTAT-C statistical package. Data on the disease percentage and severity were transformed to (X+1) under root to reduce heterogeneity of variances and to overcome zero readings (Steel and Torrie, 1960). Analysis of variance was determined by using Least significant differences(LSD) to determine the mean separations of separated means. The level of significance was calculated with an error probability of 0.05 **(Lentner and Bishop, 1993).**

Table (2)

Some characteristics of soil, poultry manure, sheep manure, and irrigation water before initiation of the experiment.

Characteristics	Soil in pots	Poultry manure	Sheep manure	Irrigation water
Texture	**Sandy clay loam**	**n.d****	**n.d**	**n.d**
pH	**7.6**	**5.9**	**6.8**	**6.84**
EC (ms/cm)	**1.35**	**2.14**	**4.46**	**1.11**
Total-N (%)	**0.35**	**32.2**	**7.8**	**n.d**
P (ppm)	**135**	**212**	**170**	**n.d**
K (ppm)	**266**	**371**	**471**	**n.d**
Organic matter (%)	**1.55**	**78.33**	**84.3**	**n.d**

***n.d: not determined**

Chapter four
Results and discussions

4.1. Vegetative growth
4.1.1. Fresh and dry weight

Generally shoot fresh weight increased with poultry manure, and sheep manure compared with non organic soil amendment (Table 3). The highest shoot fresh weight (13.68 gm/plant) was produced by the application of 40 ton / ha of poultry manure with bio-control *Trichoderma harzianum* in the absence of phytophthora, while the lowest weight (8.577 gm/plant)was obtained with application sheep manure at rate 40 ton/ha with Trichoderma addition in the presence of phytophthora soil amendment was produced at 40 ton/ha sheep treatment.

Root fresh weight increased with poultry, and sheep manures compared with non amendment (Table 3).Fresh weight of root significantly increased with poultry manure compared with non amendment, while with sheep manure, fresh weight of root tended to increased insignificantly (Table 3). The highest root fresh weight (4.907 gm/plant) was produced by the application of 40 ton /ha of poultry manure and with bio-control (*Trichoderma harzianum*) has ability to decompose manure as soil saprophyte, and the lowest weight (3.267 gm/plant) was produced by application 2 tons of sheep manure with presence of pathogen and the absent of bio-control. In general, vegetative fresh weight increased with increasing rates of poultry manure and bio control (*Trichoderma harzianum*.

High yield for extended periods of crop cultivation in areas were associated with the use of organic source of fertilizer. Vegetative fresh weights of shoot and root were increased with soil amendments application (Table 3).Data of the present study showed that poultry manure is considered the best soil amendment increasing for shoot and root fresh weight. This might be attributed to the ability of organic soil amendment to improve soil by changing the physical, chemical, and biological environments in the soil. Organic material stimulates plant root growth, increases nutrient uptake, decreases evaporation from the soil, increases soil water-holding capacity, reduces surface water runoff, facilitates drainage, regulates soil temperature, and provides a rich substrate for soil microbes (Chen, 1988, Chen, 1987, Ribeiro, 1991). Addition of chicken manure significantly increased vegetative growth of brassica species(B. Carinta A.Br.and B. oleracea L.) compared with compost prepared from olive mill and cotton wastes(Walker and Bernal, 2004). Fresh and dry weight of tomato(plant and fruit) indicated a clear increase with application farmyard manure compared with other treatments(Radwan *et al*.,1993).

Mahadeen.,(2009) found that fresh and dry weights of strawberry shoot were significantly increased with the addition of organic manure.

Adding *Trichoderma harzianum* soil amendment increased fresh weights of shoot and root of strawberry (Table 3), these increment in plant growth in the presence of *Trichoderma harzianum* might be due to its ability to decompose organic manure the elimination of minor *Phytophthora fragaria* in the rhizosphere.in no pathogen that was also differences However, the soil used in this study was pasteurized before infestation, thus, minimizing any contamination by other pathogens. The obtained result agrees with the studies of Chang *et al*, (1986); Inbar *et al*., 1994), the possible explanation of this phenomenon includes control of minor pathogens leading to stronger growth and nutrient uptake (Ousley *et al*, 1993). Of present study the results indicated that *T. harzianum* had a positive effect on strawberry growth.An alternative possibility for such increased in plant growth was suggested by, Windham *et al*,(1986), who found that *Trichoderma* spp produced a growth-regulating factor that increased the fresh weight of shoot and root.

Table (3)
Effects of organic soil amendment, *Trichoderma harzianu* and *Phytophthora fragaria* on shoot and root fresh weight 0f strawberry plant .

Soil amendment and level (tons/ha)	*Trichoderma*	*Phytophthora*	Shoot fresh weight (gm/plant)	Root fresh weight (gm/plant)
Control (0)	+ *Trichoderma*	+ *Phytophthora*	9.44 defg	3.657 cdef
		- *Phytophthora*	11.42 bcde	3.743 bcdef
	- *Trichoderma*	+ *Phytophthora*	8.940 g	3.283 f
		- *Phytophthora*	10.72 bcdefg	3.493 ef
Poultry (20)	+ *Trichoderma*	+ *Phytophthora*	10.60 bcdefg	4.027 abcde
		- *Phytophthora*	12.13 abc	4.903 a
	- *Trichoderma*	+ *Phytophthora*	10.61 bcdefg	3.933 abcdef
		- *Phytophthora*	11.54 abcd	4.213 abcd
Poultry (40)	+ *Trichoderma*	+ *Phytophthora*	11.23 bcdef	4.383 ab
		- *Phytophthora*	13.68 a	4.907 a
	- *Trichoderma*	+ *Phytophthora*	10.09 cdefg	3.577 def
		- *Phytophthora*	11.35 bcde	4.300 abc
Sheep (20)	+ *Trichoderma*	+ *Phytophthora*	9.457 defg	3.423 ef
		- *Phytophthora*	12.01 abc	3.863 bcdef
	- *Trichoderma*	+ *Phytophthora*	9.307 efg	3.267 f
		- *Phytophthora*	9.383 defg	3.760 bcdef
Sheep (40)	+ *Trichoderma*	+ *Phytophthora*	10.00 cdefg	3.357 ef
		- *Phytophthora*	12.72 ab	4.370 abc
	- *Trichoderma*	+ *Phytophthora*	8.577 g	3.453 ef
		- *Phytophthora*	9.030 fg	3.797 bcdef

*Means within rows and columns having the same letter are not significantly different at 0.05. according to LSD.

The results presented in (table 4) revealed that dry weight of shoot increased with addition of the two types of manure. Poultry manure increased the dry weight compared with the sheep manure. Dry weight of shoot significantly increased with application 40 tons/ha of poultry and when the bio control was present and the pathogen was absent compared

with all other treatments except (20 tons/ ha of poultry and 40 tons / ha of sheep The highest value of shoot dry weight reached (7.077) gm/plant was obtained by application 40 ton/ha poultry manure with presence of Trichoderma in the absence of pathogen. Adding bio- control with or without pathogen were tended to increase regardless of organic manure increased dry weight of plant was not significantly affected in some treatments.

Table 4 showed that root dry weight significantly increased with organic manure levels compared with control. When the pathogens where appeared, the root dry weight decreased. The application of 40 ton /ha of poultry and sheep manures with addition of bio-control (*Trichoderma harzianum*) significantly increased root dry weight compared with control .

The application of poultry manure with addition of bio-control (*Trichoderma harzianum*) significantly increased dry weight of shoot and root (Table4). This might be due to the fact that manure provides plant with different nutrients, and might be due to the improvement of soil water holding capacity . According to highest total yield and quality of broccoli were recorded by adding poultry manure in the two seasons. Similar to the current results, using poultry manure with Southern star cv. gave the highest total yield and quality of broccoli (Abou El- Magd, *et al*.2006).

Application of bio-control increased the dry weights of strawberry shoot and root. One of the most important characteristics necessary for acceptance and effectiveness of bio-control agents is their ability to survive in the environments other than their origin and colonize plants roots during certain period of time to control plant pathogens (Nemec *et al*., 1996). This may be attributed to the ability of *Trichoderma* to mobilize and take up soil nutrients and protect the roots from attacked by the pathogen. This study was in agreements, with the studies of Lewis *et al*., (1998) ; Al-Ameiri, (2001), 2007 and 2009) who that found *Trichoderm harizanum* increased shoot dry weight of cucumber .

Table (4)
Effects of organic soil amendment , *Trichoderma harzianum* and *Phytophthora fragaria* on shoot and root dry weight of strawberry plant .

Soil amendment types and level (tons/ha)	*Trichoderma*	*Phytophthora*	Shoot dry weight (gm/plant)	Root dry weight (gm/plant)
Control (0)	+ *Trichoderma*	+ *Phytophthora*	4.983 ghij	1.733 d
		- *Phytophthora*	6.067 bcdef	1.933 bcd
	- *Trichoderma*	+ *Phytophthora*	4.847 ghij	1.723 d
		- *Phytophthora*	4.700 hij	1.833 cd
Poultry (20)	+ *Trichoderma*	+ *Phytophthora*	5.683 bcdefg	2.327 abc
		- *Phytophthora*	6.493 ab	2.130 abc
	- *Trichoderma*	+ *Phytophthora*	5.520 cdefgh	1.997 abcd
		- *Phytophthora*	5.283 efghi	1.983 abcd
Poultry (40)	+ *Trichoderma*	+ *Phytophthora*	6.143 bcde	2.353 ab
		- *Phytophthora*	7.077 a	2.477 a
	- *Trichoderma*	+ *Phytophthora*	5.290 defghi	1.710 d
		- *Phytophthora*	6.133 bcdef	2.200 abc
Sheep (20)	+ *Trichoderma*	+ *Phytophthora*	5.067 ghi	1.800 d
		- *Phytophthora*	6.167 bcd	1.967 abcd
	- *Trichoderma*	+ *Phytophthora*	4.900 ghij	1.767 d
		- *Phytophthora*	4.167 j	1.733 d
Sheep (40)	+ *Trichoderma*	+ *Phytophthora*	5.067 ghi	1.800 d
		- *Phytophthora*	6.253 abc	2.392 a
	- *Trichoderma*	+ *Phytophthora*	4.567 ij	1.733 d
		- *Phytophthora*	5.260 fghi	1.767 d

*Means within rows and columns having the same letter are not significantly different at 0.05. according to LSD.

Table (5)

Main effects of organic soil amendment, *Trichoderma harzianum* and *Phytophthora fragaria* on shoot and root fresh and dry weight of strawberry plant(gm/plant .

Treatments		Shoot weight (gm/plant)		Root weight(gm/plant)	
		Fresh	Dry	Fresh	Dry
Soil organic amendment(ton/ha)					
Control	0	10.4 b	5.4 b	3.95 b	2.2 a
Poultry	20	11.3 a	5.8 a	3.98 a	2.1 ab
	40	11.4 a	6.0 a	4.40 b	2.0 bc
Sheep	20	9.9 b	5.8 b	3.59 c	1.84 cd
	40	9.9 b	5.1 b	3.49 c	1.74 d
LSD(0.05)		0.85	0.34	0.28	0.19
Phytophthora					
	-	11.398 a	5.8 a	4.1 a	2.1 a
	+	9.825 b	5.2 b	3.6 b	1.9 a
LSD(0.05)		0.41	0.31	0.4	0.23
Trichoderma					
	-	10.5 a	5.4 a	3.8 a	1.9 a
	+	10.7 a	5.6 b	4.0 a	2.0 a
LSD(0.05)		0.33	0.12	0.21	0.13

- **For each factor, within each column, values having different letter are significantly different at $P \leq 0.05$ according to LSD.**

4.2.2. Leaves number per plants

Number of strawberry leaves was significantly affected by soil amendment types and levels and *Trichoderma* (Table 6).The highest number of leaves per plant **(12.83g/plant)** was obtained by the high poultry manure level with application of bio-control without pathogen. This treatment gave the highest weight (12.83) The lowest leaves number (**5.0**g) was obtained without animal manures and bio-control with pathogen. Leaves number was significantly increased when the bio-control were added (Table 6). Application different types of organic manures with application of beneficial microorganism(Trichoderma harizanum) increased leaves number of the strawberry plants more than organic manures only, this results were not in agreement with result obtained by Abu-Zahra and Tahboub,(2008), who found that the poultry manure produced less leaf numbers than sheep manure. This might be attributed to differenence of

strawberry cultivar , location and the period of experiment. However ,present results were in agreement with those results of, (Azarmi, *et al*. (2009) who found that poultry manure where increased leaf number of cucumber (*Cucumis sativus* L.) under green house conditions.Also Chanda *et al*.(2011). showed that the used of Organic fertilizers increased fresh and dry weight of leaves, number of branches, tomato plant compared with chemical fertilizers, El-Mansi *et al*.,(1999). found that the application of 25 m^3 of farmyard manure/fed significantly favoured both branches and leaves/plant in pea compared with 0 and 12.5 ton/fed .

4.2.3. Runner numbers per plant

Application of soil organic amendments insignificantly increased number of runners. The highest runner numbers (4.667) was obtained with the treatment of 40 tons/ ha of poultry manure with bio control and without pathogen (Table 6) . The lowest significant runner number (2.000) was obtained by the 20 tons/ha of sheep manure treatments with pathogen. No significant differences where observed in the runner numbers between the same sheep manure treatments when the pathogen was absent.

The present data showed that poultry manure is a valuable fertilizer and can serve as a suitable alternative to chemical fertilizer of the strawberry. This results is in agreement with the result of Joy Nwakaego, *et al*, (2011) .who found that the organic manures increased the number of branch / plant when used as a fertilizers on Cassava plant.

4.2.4. Leaf area:

Leaf area was significantly affected by the main effect of poultry manure level (Table 6). The highest leaf area reached to 17.430 cm^2 under the treatments of 40 tones/ha of poultry manures, while the lowest value (6.367 cm^2) was observed in control treatment when the manures and bio-control absent and the pathogen where added. Leaf area was significantly increased at 40 tones/ha poultry manure (17.430 cm^2**)** compared with other treatments when the pathogen was absent and added bio-control In general, each increase in poultry and sheep manure levels significantly increases leaf area Table (6). Leaf area was increased in all treatments when the bio- control added to the soil with or without pathogens .

The results in Table (6) showed the significant effect of soil organic amendments and bio-control on leaf area. This might the due to protection of roots from pathogen by the bio agents and absorption water and elements from soil due to addition of poultry and sheep manures .these materials transmitted and accumulated throw the root to the shoot system and increased divided of leaf and the area where increased. This results is in harmony with that obtained by Norman *et al*., (2003) reported that there was significant increased in leaf area of strawberry , and pepper plant from

plots treated with organic vermicompost compared with those from plots treated with chemical fertilizer only**.**, Abdelrazzag (2002). this might be due to the fact that manure provides suitable nutrient to the plant Lekas *et al*.,(1998). and Ouda and Mahadeen (2008) found that addition of the high levels of chemical fertilizer (60 or 100 kg/ha) combined with 25 ton/ha of organic fertilizer resulted in largest leaf area (Mahadeen .,2009).

Table (6)

Effects of organic soil amendment , *Trichoderma harzianum* and *Phytophthora fragaria* on number of leaves, number of runners and leaf area of strawberry plant.

Soil amendment types and level (tons/ha)	*Trichoderma*	*Phytophthora*	No of leaves / plant	No of runners / plant	Leaf area (cm^2)
Control (0)	+ *Trichoderma*	+ *Phytophthora*	7.000 fg	2.667 c	7.067 ghi
		- *Phytophthora*	9.333 cde	3.333 abc	7.567 fghi
	- *Trichoderma*	+ *Phytophthora*	5.000 g	2.333 c	6.367 ghi
		- *Phytophthora*	5.667 g	3.000 be	7.300 ghi
Poultry (20)	+ *Trichoderma*	+ *Phytophthora*	9.500 cd	3.333 abc	9.533 de
		- *Phytophthora*	11.83 ab	4.333 ab	14.000 b
	- *Trichoderma*	+ *Phytophthora*	6.333 fg	2.333 c	6.500 i
		- *Phytophthora*	6.500 fg	3.000 bc	8.267 efghi
Poultry (40)	+ *Trichoderma*	+ *Phytophthora*	12.50 ab	3.333 abc	9.930 d
		- *Phytophthora*	12.83 a	4.667 a	17.430 a
	- *Trichoderma*	+ *Phytophthora*	8.167 def	3.000 bc	7.400 ghi
		- *Phytophthora*	8.000 def	4.333 ab	8.367 efg
Sheep (20)	+ *Trichoderma*	+ *Phytophthora*	7.167 efg	3.000 bc	7.667 fghi
		- *Phytophthora*	10.50 bc	3.333 abc	11.570 c
	- *Trichoderma*	+ *Phytophthora*	6.667 fg	2.000 c	6.767 i
		- *Phytophthora*	6.000 fg	3.333 abc	6.867 hi
Sheep (40)	+ *Trichoderma*	+ *Phytophthora*	9.333 cde	3.000 bc	8.900 def
		- *Phytophthora*	11.17 abc	3.333 abc	14.630 b
	- *Trichoderma*	+ *Phytophthora*	6.833 fg	2.333 c	7.300 ghi
		- *Phytophthora*	6.000 fg	3.333 abc	7.533 fghi

*Means within rows and columns having the same letter are not significantly different at 0.05. according to LSD.

Table (7)

Main effects of organic soil amendment, *Trichoderma harzianum* and *Phytophthora fragaria* on leaves number, leaf area and number of runners of strawberry plant.

Treatments		Leaves Numbers	Leaves Area	Numbers of runners
Soil organic amendment(ton/ha)				
	0	**6.83 d**	**7.10 d**	**3.16 ab**
Poultry	**20**	**8.58 b**	**9.79 b**	**3.08 a**
	40	**10.08 a**	**10.78 a**	**3.66 b**
Sheep	**20**	**8.33 bc**	**8.21 c**	**3.00 b**
	40	**7.62 cd**	**9.59 b**	**2.91 b**
LSD(0.05)		**0.87**	**0.91**	**0.53**
Phytophthora	**-**	**8.633 a**	**10.353 a**	**3.600 a**
	+	**7.950 b**	**7.843 b**	**2.733 b**
LSD(0.05)		**0.65**	**1.6**	**0.8**
Trichoderma	**-**	**7.150 b**	**7.367 b**	**3.067 a**
	+	**9.433 a**	**10.830 a**	**3.267 a**
LSD(0.05)		**1.12**	**1.5**	**0.3**

For each factor, within each column, values having different letter are significantly different at *P*≤0.05 according to LSD.

Application of soil amendment and biological control to strawberry seedlings showed increase effect on N content of shoot and root. and (Table 8, 9). Both of treatments poultry manure (40 ton/ha) N content increased with out significantly(4.55 %) and (3.317 %), in shoot and root respectively with out pathogen and biological control, when biological control added only significantly increased N content (4.550 %) and (3.317 %), in shoot and root, respectively, in the other hand, sheep manure (40 ton /ha) significantly increased N content (2.027%) and (1.183 %), in shoot and root respectively with out pathogen and with biological control (3.417 %) and (2.343 %), in shoot and root respectively , the poultry manure (20 ton/ha)give also significantly increased N content when the bio- control added and with absent pathogen. Treatment had the lowest effect sheep manure (20 ton/ha) on N content compare with other treatments (8, 9). These results could be due to the higher concentration of inorganic N in manure with respect to the compost, which is easily nitrified and also the

mineralization of the organic N being particularly fast in manure. Soil amendment with manure increase the available nitrogen in the autosphere of plant roots and it easy to absorption by plant. The amount of nitrogen in soil affected by the soil manure amendment, The highest N content (40 tons /ha) in poultry manure is gave good parameter .These results are in good line with those obtained by (Walker and Bernal, 2007) and (El-Dewiny *et al.,* 2006).

Also,Ouda and Mahadeen.(2008) found that broccoli leaf nitrogen content was increased by the application of organic manure and chemical fertilizer, and Mahadeen, (2009). Found that the highest strawberry leaf-N content obtained with application of 25 ton/ha of organic manure(Mahadeen.,2009).Also, Maftoun *et al*.,(2004) indicated that the concentration of N in the spinach plant increased with increasing the level of poultry manure. Bar-Tal *et a*l.(2004) reported that the amount of N,P and K up take by wheat plants was increased with increasing compost rates up to 3 ,6 and 12 kg /m^2.Nitrogen content of onion tissues were been found to be increased with increasing the application rate of chicken and sheep manure (12.5 ,25,and 80 ton / ha) (Abdelrazzag ,2002).

Table (8)

Effects of organic soil amendment, *Trichoderma harzianum* and *Phytophthora fragaria* on shoot macronutrient (N , P and K) content of strawberry plant.

Soil amendment and level	*Trichoderma*	*Phytophthora*	N (%)	P (ppm)	K (ppm)
Control (0)	+ *Trichoderma*	+ *Phytophthora*	1.670 f	769.0 ab	417.7 ghi
		- *Phytophthora*	2.173 def	781.3 ab	429.0 def
	- *Trichoderma*	+ *Phytophthora*	1.633 f	766.0 ab	408.2 m
		- *Phytophthora*	1.637 f	778.3 ab	420.7 g
Poultry (20)	+ *Trichoderma*	+ *Phytophthora*	2.973 bcde	764.7 b	427.3 ef
		- *Phytophthora*	3.790 ab	782.3 ab	436.0 b
	- *Trichoderma*	+ *Phytophthora*	2.063 def	763.7 b	413.3 jkl
		- *Phytophthora*	1.867 ef	776.3 ab	430.2 cde
Poultry (40)	+ *Trichoderma*	+ *Phytophthora*	3.160 bcd	768.0 ab	430.3 cde
		- *Phytophthora*	4.550 a	787.7 a	444.7 a
	- *Trichoderma*	+ *Phytophthora*	2.720 bcdef	765.3 b	416.5 hij
		- *Phytophthora*	2.037 def	782.3 ab	431.5 cd
Sheep (20)	+ *Trichoderma*	+ *Phytophthora*	1.903 ef	764.0 b	414.0 ijk
		- *Phytophthora*	2.463 cdef	782.0 ab	433.2 bc
	- *Trichoderma*	+ *Phytophthora*	1.637 f	761.3 b	409.71 m
		- *Phytophthora*	1.620 f	780.3 ab	426.2 f
Sheep (40)	+ *Trichoderma*	+ *Phytophthora*	2.510 cdef	762.3 b	419.8 gh
		- *Phytophthora*	3.417 abc	782.0 ab	433.8 bc
	- *Trichoderma*	+ *Phytophthora*	2.023 def	731.7 c	410.3 klm
		- *Phytophthora*	2.027 def	780.7 ab	432.2 bcd

*Means within rows and columns having the same letter are not significantly different at 0.05. according to LSD.

Table (9)

Main effects of organic soil amendment , *Trichoderma harzianum* and *Phytophthora fragaria* on shoot and root macronutrient concentration (N, P and K) content of strawberry plant.

Treatments		N (%)		P (ppm)		K (ppm)	
		Shoot	Root	Shoot	Root	Shoot	Root
Soil organic amendment(ton/ha)							
control		1.77 d	1.33 c	773.7 a	322 c	422.4 cd	348 a
	0	2.72 ab	1.82 b	771.6 ab	447 b	423.3 bc	387 bc
Poultry	20	3.06 a	2.55 a	775.8 a	595 a	430 a	530 b
	40	2.01 cd	1.51 bc	771.9 ab	351 c	421.6 d	274 c
Sheep	20	2.39 ab	1.70 bc	764.1 b	352 c	424 b	324 bc
	40	0.44	0.39	8.4	45	15	110
LSD(0.05)							
	-	2.558 a	1.919 a	781.33 a	524 a	431.73 a	402 a
Phytophthora							
	+	2.233 a	1.656 a	761.60 a	339 b	416.71 b	343 b
LSD(0.05)		0.4	0.3	22	60	13	35
	-	1.953 b	1.536 b	770.367 a	308 b	420 b	338 b
Trichoderma							
	+	2.838 a	2.039 a	772.567 a	556 a	427 a	470 a
LSD(0.05)							
		0.22	0.25	15	60	5	42

*** For each factor, within each column, values having different letter are significantly different at *P*≤0.05 according to LSD.**

Shoot and root P contents were affected by the two amendments and their interaction with the bio-control. Addition of 40 ton/ha poultry manure with Trichoderma and without infection with phytophthora gave the highest P content(787.7 ppm) On the contrary Application of 40 ton/ha sheep manure in presence of *phytophthora* and *Trichoderma* gave the lowest shoot p content. *Trichoderma* alone has no significant influence on shoot p content.

Concerning root p content, the results showed that application of 40 ton/ha poultry manure significantly increased it compared to the control. However, application of 40 ton/ha significantly reduced root p content. The

interaction between amendment and *Trichoderma* significantly increased root p content either in presence or absence of *phytophthora*.

Poultry manure is a valuable fertilizer and can serve as a suitable alternate to chemical fertilizer, other treatment was not significantly affected by soil amendment type and bio-control in shoot and root of strawberry. It was also indicated that poultry manure is more readily supplies P to plants than other organic manure sources. These results are in harmony with Garg and Bahla (2008), who reported an increase in the p content of tomato shoot plant with poultry manure. Ether agreement with the results of Roe and Cornforth (2000) and Kahn *et al*. (2005) who reported that phosphorus content in leaf depends on the availability of P in type of manure and composting time (Table 10). Preusch *et al*.(2004) reported that leaf P in strawberry plant treated with composted and fresh poultry litter was higher than synthetic fertilizer.

Table (10)

Effects of organic soil amendment , *Trichoderma harzianum* and *Phytophthora fragaria* on root macronutrient (N , P and K) content of strawberry plant.

Soil amendment types and level (tons/ha)	*Trichoderma*	*Phytophthora*	N content in root (%)	P content in root (ppm)	K content in root ppm)
Control (0)	+ *Trichoderma*	+ *Phytophthora*	1.247 def	0.4700 b	0.5833 ab
		- *Phytophthora*	1.643 cdef	0.4867 b	0.5200 abc
	- *Trichoderma*	+ *Phytophthora*	1.017 ef	0.1233 e	0.5167 abc
		- *Phytophthora*	1.437 cdef	0.2207 d	0.5000 abc
Poultry (20)	+ *Trichoderma*	+ *Phytophthora*	1.690 cdef	0.4033 b	0.1533 ef
		- *Phytophthora*	3.047 ab	0.2767 d	0.3900 bcdef
	- *Trichoderma*	+ *Phytophthora*	1.650 cdef	0.3600 bc	0.1400 f
		- *Phytophthora*	0.930 f	0.2500 d	0.3967 bcdef
Poultry (40)	+ *Trichoderma*	+ *Phytophthora*	3.003 ab	0.4367 b	0.4667 bcd
		- *Phytophthora*	3.317 a	0.6700 a	0.7667 a
	- *Trichoderma*	+ *Phytophthora*	2.073 bcd	0.2567 d	0.2600 cdef
		- *Phytophthora*	1.830 cdef	0.3700 bc	0.3700 bcdef
Sheep (20)	+ *Trichoderma*	+ *Phytophthora*	1.297 def	0.4600 b	0.3633 bcdef
		- *Phytophthora*	1.747 cdef	0.3700 bc	0.2367 cdef
	- *Trichoderma*	+ *Phytophthora*	1.287 def	0.3700 bc	0.2300 cdef
		- *Phytophthora*	1.710 cdef	0.2033 d	0.1933 def
Sheep (40)	+ *Trichoderma*	+ *Phytophthora*	1.973 cde	0.2533 d	0.4367 bcde
		- *Phytophthora*	2.343 abc	0.3467 c	0.3700 bcdef
	- *Trichoderma*	+ *Phytophthora*	1.323 cdef	0.1433 e	0.2833 cdef
		- *Phytophthora*	1.183 def	0.1767 e	0.2800 cdef

*Means within rows and columns having the same letter are not significantly different at 0.05. according to LSD.

Values of K content significantly influenced by the soil amendment application and its interaction with the bio-control (Table 8, 10).The highest shoot and root K contents, (444.7 and 0.7667 ppm, respectively) were obtained by application of 40 ton/ha poultry manure with the bio-control.

Application of *Trichoderma* significantly increased shoot K content either in presence or absence of *phytophthora* .However, root K content was in significantly increased in presence of *Trichoderma.*

Poultry manure increased the survival rate of *Trichoderma harizanum*. Manure treatments significantly increased soil organic matter levels, not all manures suppressed pathogen populations or seedling symptoms. Organic matter provided by manure is high quality because of its cellulose content and level of available energy and supports the growth of suppressive microbes (Hoitink, 1999).

These results are similar to those obtained by (Roe and Cornforth, (2000), (Walker and Bernal, (2007) and (El-Dewiny *et al,* (2006). Possible explanation of the results is that exchangeable K increased significantly with manure application and can be related to the increase in electrical conductivity.

Disease assessments

Addition of *Trichoderma harzianum* to soil with all treatments significantly reduced disease percentage (Table 11). In the soil only with the pathogen disease percentage reached 70% while with bio control reached 53.3 and where highly significantly. Soil amendment and biological control which added to strawberry seedlings showed highly significantly reduced disease percentage with all treatment except addition of poultry manure at 40 ton/ha. Disease percentage reduced significantly with increase the amount of soil amendment with or without *Trichoderma harzianum* compared to soil only. Disease percentages with *Trichoderma harzianum* decreased to 44% with added 40 ton/ha of poultry manure (Table 11).

Disease severity significantly increased with *Phytophthora fragaria* under soil amendment compared with soil only except (20 tons/ha) of sheep (Table 11). There was significant difference between *Trichoderma harzianum* added to soil or not added. There was no significant difference between *Trichoderma harzianum* added to soil with soil amendent.but the severity decreased significant at increase type of soil amendment. One of the most appealing attributes of compost is its potential to suppress plant diseases by improving the biological health of the soil. Healthy soils indeed produce healthy plants. In general, compost amended soils do not eliminate plant pathogens; but, when organic amendments are effective in controlling plant diseases, pathogens do not cause economically important losses. There are several ways in which organic matters in the soil can indirectly control *Phytophthora*, namely:1) Increasing the activity of the indigenous microflora, resulting in suppression of pathogen population through competition or specific inhibition (Konam and Guest, 2002; Broadbent and Baker, 1974); 2) releasing degrading compounds such as carbon dioxide, ammonia, nitrites, saponins or enzymes that are generally toxic to *Phytophthora* (Tsao and Oster, 1981); 3)

Acting as a trap, since *Phytophthora* will be attracted to and encyst on organic matter (Grant *et al.*, 1985); 4) Inducing plant defence mechanisms (Gilpatrick, 1969); and 5) Creating an environment that stimulates root development by physically inhibiting *Phytophthora* (Turner and Menge, 1994).

A majority of the soil amendment with manure significantly reduced diseases percentage and severity resulted that compost considered being

Table (11)

Effects of organic soil amendment , *Trichoderma harzianum* and *Phytophthora fragaria* on disease severity and disease percentage in strawberry plant.

types Soil amendment and level (tons/ha)	*Trichoderma*	*Phytophthora*	Disease severity	Disease percentage
Control (0)	+ *Trichoderma*	+ *Phytophthora*	0.47 c	53.3 bc
		- *Phytophthora*	0.0 c	0.0 f
	- *Trichoderma*	+ *Phytophthora*	0.67 a	70.0 a
		- *Phytophthora*	0.0 c	0.0 f
Poultry (20)	+ *Trichoderma*	+ *Phytophthora*	0.33 d	33.3 e
		- *Phytophthora*	0.0 c	0.0 f
	- *Trichoderma*	+ *Phytophthora*	0.53 b	56.7 b
		- *Phytophthora*	0.0 c	0.0 f
Poultry (40)	+ *Trichoderma*	+ *Phytophthora*	0.27 e	30.0 e
		- *Phytophthora*	0.0 c	0.0 f
	- *Trichoderma*	+ *Phytophthora*	0.43 cd	40.0 de
		- *Phytophthora*	0.0 c	0.0 f
Sheep (20)	+ *Trichoderma*	+ *Phytophthora*	0.37 d	36.7 e
		- *Phytophthora*	0.0 c	0.0 f
	- *Trichoderma*	+ *Phytophthora*	0.57 ab	56.7 b
		- *Phytophthora*	0.0c	0.0 f
Sheep (40)	+ *Trichoderma*	+ *Phytophthora*	0.30 d	33.3 e
		- *Phytophthora*	0.0c	0.0 f
	- *Trichoderma*	+ *Phytophthora*	0.50 b	46.7 d
		- *Phytophthora*	0.0 c	0.0 f

*Means within rows and columns having the same letter are not significantly different at 0.05. according to LSD.

Table 12: Main effects of organic soil amendment, *Trichoderma harzianum* and *Phytophthora fragaria* on disease severity and disease percentage in strawberry plant.

Treatments		Disease infection (%)	Disease severity
Soil organic amendment(ton/ha)			
	0	**30.8 a**	**0.29 a**
Poultry	**20**	**22.5 b**	**0.22 b**
	40	**17.5 c**	**0.18 b**
Sheep	**20**	**23.4 bc**	**0.24 b**
	40	**20.1 bc**	**0.20 b**
LSD		**1.5**	**0.05**
Phytophthora	**-**	**0.0 b**	**0.0 b**
	+	**53.7 a**	**0.45 a**
LSD		**17**	**0.25**
Trichoderma	**-**	**55 a**	**0.27 a**
	+	**19 b**	**0.17 b**
LSD		**9**	**0.09**

For each factor, within each column, values having different letter are significantly different at *P*≤0.05 according to LSD.

Commercially viable for controlling root rot diseases pressure. However, I found that the highest levels of total biological activity, in chicken manure composted for(40 tons/ha), while biological activity and pathogen activity were lowest in low manure application. High soluble nitrogen, phosphorus, and potassium (Casale, W. L., Minassian, V., Menge, J. A., Lovatt, C. J., Pond, E., Johnson, E., and Guillemet, F. 1995.). Three different forms of nitrogen (ammonium, nitrite, and nitrate) inhibit *P.cinnamomi*, both in soils and in vitro (Tsao and Oster ., 1981) Found that ammonia (pH 8.0) inhibited *Phytophthora* spp. in soil.

High levels of ammonia in chicken manure are directly toxic to *Phytophthora*; however, leaching and volatilization of ammonia during composting enables the growth of fast-growing saprophytes as well as

pathogens that utilize readily available sugars. The results show that *Trichoderma harzianum* applied to soil amendment with manure infested with *Phytophthora fragaria* decreased diseases percentage and severity (Table 11). *Trichoderma spp.* applied to soil as wheat seed infested decreased disease incidence and severity more than conidia. This is attributed to that they are containing young activity growing hyphae and abundant of chlamydospores, the hyphae already occupying the food base do not appear to be subjected to fungistases and that direct contact between mycelium and food base enable the antagonistic to grow through the soil (Lewis and Papavizas, 1983, 1984 and 1985; Papavizas *et al*., 1984; and Al-Ameiri, 2001). Often have negative effects on plant health for some time after their application to soils and can increase disease incidence and severity, these results showed that the increase in diseases incidence and severity occurred with application of manure to infested soil without bio-control. This means that the pathogen utilized the food base (animal manure) and increased its population because of the ability of *Phytophthora* spp. to live as saprophyte fungi and increase infections of hosts (Holmes *et al*., 1998; and Al-Amieri , 2001).

4.2 recommendations

The present study was carried out under partially controlled glasshouse conditions at the Agricultural Research Station, Faculty of Agriculture, Mu'tah University in the growing season 2011-2012. This work was conducted to investigate the effect of organic soil amendment and *T. harzianum* on strawberry growth and root rot caused by *P. fragariae*.

The following results could be concluded from the investigation:

1. Fresh and dry weight as well as leaf area of strawberry plants enhanced by organic manures.
2. Using the bio-control agent, *T. harzianum* reduced the root rot diseases caused by *P. fragariae*.
3. Both sources of organic manure; poultry and sheep, had a positive effect on soil and plant. However, application of poultry manure resulted in a higher nutrient content in strawberry.
4. Poultry and sheep manures have a potential as an organic fertilizer because of their nutritional contents. Application of poultry and sheep manures to the soil in adequate amounts improves soil fertility; physical and biological properties as soil amendments eventually increase strawberry production growth.
5. Interaction between a bio-control and manures gave beneficial advantages.

6. This present study suggests that manure can be used as an alternative system for chemical fertilizers and chemical fungicide for pathogen in soil caused root rot.
7. Further investigations are needed to determine optimal rates of the amendment improving organic manure quality, and developing method of manure utilization.

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Appendix (I)

Analysis of variance for the effect of soil amendment, pathogen and bio- control and their interaction on shoot and root weight of strawberry plant.

Appendix (I)
Analysis of variance for the effect of soil amendment, pathogen and bio

source	d.f	Mean square			
		Shoot fresh weight	**Shoot Dry weight**	**Root fresh weight**	**Root Dry weight**
Soil amendment	4	6.611	2.148	1.557	0.407
Phytophthora	1	37.131	4.593	3.735	0.363
Soil amendment x Phytophthora	4	1.049	0.927	0.114	0.147
Trichoderma	1	0.831	0.420	0.382	0.004
Soil amendment **x Trichoderma**	4	4.821	1.318	0.438	0.237
Phytophthora x Trichoderma	1	2.068	0.670	0.741	0.006
Soil amendment x Phytophthora x Trichoderma	4	4.927	2.074	0.152	0.109
Error	40	1.794	0.283	0.189	0.097
Total	59				

control and their interaction on shoot and root weight of strawberry plant.
ns: not significant and*: significant at 0.05 level .

Appendix (II)

Analysis of variance for the effect of Soil amendment, pathogen and bio control and their interaction on number of runner and leaves of strawberry plant.

Appendix (II)

Analysis of variance for the effect of Soil amendment , pathogen and bio control and their interaction on **number of runner** and **leave**s of strawberry plant.

Source	**d.f**	**Mean square**	
		Number of runner	**Number of leave**
Soil amendment	4	1.042	17.604
Phytophthora	1	11.267	7.004
Soil amendment x Phytophthora	4	1.142	1.921
Trichoderma	1	0.600	78.204
Soil amendment **x Trichoderma**	4	0.808	11.350
Phytophthora x Trichoderma	1	0.067	100.104
Soil amendment x Phytophthora x Trichoderma	4	0.775	7.750
Error	40	0.683	1.871
Total	59		

ns: not significant and*: significant at 0.05 level .

Appendix (III)
Analysis of variance for the effect of soil amendment, pathogen and bio -control and their interaction on macro nutrient contents (N , P and K uptake of strawberry shoot.

Appendix (III)

Analysis of variance for the effect of soil amendment, pathogen and bio - control and their interaction on macro nutrient contents (N, P and K uptake of strawberry shoot.

Source	d.f	Mean square		
		N %	P (ppm)	K (ppm)
Soil amendment	4	3.238	232.445	136.256
Phytophthora	1	1.584	5841.067	3382.504
Soil amendment x **Phytophthora**	4	0.041	219.192	89.285
Trichoderma	1	11.748	72.600	745.537
Soil amendment **x** **Trichoderma**	4	1.265	163.392	30.985
Phytophthora x **Trichoderma**	1	4.643	64.067	152.004
Soil amendment x **Phytophthora x** **Trichoderma**	4	0.383	193.442	154.140
Error	40	0.494	173.283	5.563
Total	59			

ns: not significant and*: significant at 0.05 level .

Appendix (IV)

Analysis of variance for the effect of soil amendment, pathogen and bio- control and their interaction on macro nutrient contents (N , P and K uptake of strawberry root.

Appendix (IV)
Analysis of variance for the effect of soil amendment, pathogen and bio- control and their interaction on macro nutrient contents (N, P and K uptake of strawberry root.

Source	d.f	Mean square		
		N %	**P (ppm)**	**K (ppm)**
Soil amendment	4	2.639	0.282	0.113
Phytophthora	1	1.035	0.515	0.052
Soil amendment x **Phytophthora**	4	0.096	0.701	0.103
Trichoderma	1	3.800	0.923	0.071
Soil amendment **x Trichoderma**	4	1.066	0.531	0.029
Phytophthora x Trichoderma	1	3.504	0.628	0.003
Soil amendment x **Phytophthora x Trichoderma**	4	0.641	0.708	0.080
Error	40	0.386	0.505	0.031
Total	59			

ns: not significant and*: significant at 0.05 level .

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